Lesson Plan: Heat Transport in the Atmosphere, Hadley Circulation and Climate (Global Precipitation Patterns and Distribution of Deserts)

As a **high school** or **undergraduate Geography**, **Earth Sciences**, or **Physics** teacher, you can use this set of computer-based tools to help you in teaching about **heat transport in the atmosphere**, **atmospheric circulation**, and **the Hadley Cell and Hadley Circulation**.

Geography/Earth Sciences: The lesson plan also helps students to understand the effects of Hadley Circulation on **global precipitation patterns**, the **geographical distribution of deserts**, and **trade winds**.

Physics: The lesson plan also helps students to apply the **law of conservation of angular momentum** and understand the concept of a **thermally direct cell.**

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in Geography, Earth Sciences, or Physics.

Use this lesson plan to help your students find answers to:

- *How does the Hadley Cell transport heat in the atmosphere?*
- *Describe the geographical distribution of deserts. How does Hadley Circulation influence this distribution?*
- *What are the possible effects of climate change on Hadley Circulation?*
- *What might be the potential impacts of Hadley Cell expansion on Earth's climate, global precipitation patterns, and the geographical distribution of deserts?*

About the Lesson Plan

Grade Level	High school, Undergraduate
Discipline	Geography, Earth Sciences, Physics
Topic(s) in Discipline	Geography and Earth Sciences: Hadley Cell, Hadley Circulation, Heat Transport in the Atmosphere, Atmospheric Circulation, Global Precipitation Patterns, Geographical Distribution of Deserts, Coriolis Effect, Trade Winds, Intertropical Convergence Zone (ITCZ) Physics: Hadley Cell, Hadley Circulation, Heat Transport in the Atmosphere, Thermally Direct Cell, Law of Conservation of Angular Momentum
Climate Topic	Climate and the Atmosphere
Location	Global
Access	Online
Language(s)	English
Approximate Time Required	80 – 130 min

1 Contents

1. **Micro-lecture (video) (~7 min)**

   A micro-lecture (video) that introduces heat transport in the atmosphere and the Hadley Cell, and explains the reasons for the current geographical distribution of deserts on Earth.

   https://www.youtube.com/watch?v=GIfiCL5_9qE&list=PLZbgNdSTyWDYUZxJ3U0wQ-yvnSwtLtQqp

2. **Reading (~20 – 30 min)**

   A reading that discusses the Hadley Cell in more detail and explains a simple model for the Hadley circulation, using the law of conservation of angular momentum.

   https://www.seas.harvard.edu/climate/eli/research/equable/hadley.html

3. **Classroom/Laboratory activity (40 – 80 min)**

   A classroom/laboratory activity that uses the NASA MERRA reanalysis model for a more detailed illustration of the Hadley Circulation and its importance in Earth's climate system.

   https://pcc.uw.edu/education/classroom-resources/climate-teaching-modules/uwhs-atms-211-hadley-circulation-using-nasa-merra-reanalysis-model/

4. **Suggested questions/assignments for learning evaluation**

   - How does the Hadley Cell transport heat in the atmosphere?
   - Describe the geographical distribution of deserts. How does Hadley Circulation influence this distribution?
   - What are the possible effects of climate change on Hadley Circulation?
   - What might be the potential impacts of Hadley Cell expansion on Earth's climate, global precipitation patterns, and the geographical distribution of deserts?

2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. **Introduce the topic by playing a micro-lecture (video)**

   Introduce the topic of heat transport in the atmosphere and Hadley Cell by playing the micro-lecture "Hadley Circulation Cell" by Prof. Raghu Murtugudde, University of Maryland (content developed for the TROP ICSU project at Science Media Center, IISER Pune).

   The micro-lecture (video) "Hadley Circulation Cell" is available at https://www.youtube.com/watch?v=GIfiCL5_9qE&list=PLZbgNdSTyWDYUZxJ3U0wQ-yvnSwtLtQqp.

2. **Discuss the topic in more detail by using a reading**

   Discuss the Hadley Cell and a simple atmospheric circulation model in more detail by using the reading "Hadley Cells" from Harvard University.

   The reading applies the law of conservation of angular momentum to explain a simple model for the Hadley cell and also introduces a possible explanation for equable climates in the past (Cretaceous period).

   The reading "Hadley Cells" is accessible at https://www.seas.harvard.edu/climate/eli/research/equable/hadley.html.

3. **Conduct a classroom/laboratory exercise**

   Explore the topic in a more engaging matter by conducting the classroom/laboratory activity "Hadley Circulation using NASA MERRA Reanalysis Model" from the Program on Climate Change, University of Washington.

   In this activity, students will analyze and map real data through the NASA MERRA reanalysis model to understand the actual impact of the Hadley Cell on Earth's climate system (e.g., geographical distribution

	of deserts, global precipitation patterns, trade winds). Students will visualize 30-year-average data on winds and their vertical velocity to understand the Hadley circulation and its influence on regional climates. Download the Lab Instructions from https://pcc.uw.edu/education/classroom-resources/climate-teaching-modules/uwhs-atms-211-hadley-circulation-using-nasa-merra-reanalysis-model/ and conduct the classroom/laboratory activity described in the file.
4. Questions/Assignments	Use the tools and the concepts learned so far to discuss and determine answers to the following questions: • *How does the Hadley Cell transport heat in the atmosphere?* • *Describe the geographical distribution of deserts. How does Hadley Circulation influence this distribution?* • *What are the possible effects of climate change on Hadley Circulation?* • *What might be the potential impacts of Hadley Cell expansion on Earth's climate, global precipitation patterns, and the geographical distribution of deserts?*

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- describe the Hadley Cell and Hadley Circulation (atmospheric circulation and heat transport)
- explain the influence of the Hadley Circulation on the geographical distribution of deserts and global precipitation patterns
- discuss the potential impact of climate change on Hadley Circulation
- discuss the possible effects of Hadley Cell expansion

4 Additional Resources

If you or your students would like to explore the topic further, these additional resources will be useful.

1. **Reading, Videos** — A reading and embedded videos, "Global circulation patterns", from the Met Office, UK:

   https://www.metoffice.gov.uk/learning/atmosphere/global-circulation-patterns

2. **Reading** — A reading, "Hadley Cells", from Harvard University:

   https://www.seas.harvard.edu/climate/eli/research/equable/hadley2.html

5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and ownership details for each tool by following the individual links provided.
We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. **Micro-lecture (video), "Hadley Circulation Cell"**	Prof. Raghu Murtugudde, University of Maryland (content developed for the TROP ICSU project, at the Science Media Center, IISER Pune)
2. **Reading, "Hadley Cells"**	Harvard University
3. **Classroom/Laboratory Activity, "Hadley Circulation using NASA MERRA Reanalysis Model"**	Stephen Po-Chedley and Chris Terai, Atmospheric Sciences (2012) for the UW in the High School Climate Science Course; Program on Climate Change, University of Washington
4. **Additional Resources**	The Met Office, UK; Harvard University